

ABSTRACT OF THE DISCLOSURE

Microminiaturized semiconductor devices are fabricated with a replacement metal gate and a high-k tantalum oxide or tantalum oxynitride gate dielectric with significantly reduced carbon. Embodiments include forming an opening in a dielectric layer by removing a removable gate, depositing a thin tantalum film, as by PVD at a thickness of 25 Å to 60 Å lining the opening, and then conducting thermal oxidation, as at a temperature of 100°C to 500°C, in flowing oxygen or ozone to form a high-k tantalum oxide gate dielectric layer, or in oxygen and N₂O or ozone and N₂O ammonia to form a high-k tantalum oxynitride gate dielectric. Alternatively, oxidation can be conducted in an oxygen or ozone plasma to form the high-k tantalum oxide layer, or in a plasma containing N₂O and oxygen or ozone to form the high-k tantalum oxynitride gate dielectric layer.